

REMARKS

Claims 15, 16, 18, 22, and 24 have been cancelled. Claims 17, 19-21, and 23, which previously depended from cancelled claim 15, have been amended to depend from claim 27. No new matter has been added to the claims. Claims 1-14, 17, 19-21, 23, 26, and 27 remain pending in the application. Reconsideration and withdrawal of the rejections are requested in view of the following amendments and remarks.

Claim 1 has been amended by changing ". . . for reaction at the surface of the workpiece . . ." to -- reacting the ozone at the surface of the workpiece . . . -- to more positively describe the reacting step.

The claims describe improved cleaning methods and apparatus involving the use of a heated liquid layer on the surface of a workpiece through which large quantities of ozone diffuse to react at the surface of the workpiece. It is well known that adding heat will increase the reaction kinetics of an oxidizer, such as ozone, thereby speeding up process times. However, it is also well known that the solubility of a gas, such as ozone, in a liquid, such as water, decreases with increasing temperature. This characteristic inverse function of gas solubility versus liquid temperature suggests the use of liquid or water at room temperature or lower, in order to increase the level of dissolved ozone in the water. Indeed, various prior art techniques using chilled ozonated water have been proposed. While these techniques can achieve high levels of dissolved ozone, reaction times remain low due to the low temperatures. On the other hand, using water at high temperatures has not been effective, due to the decreasing concentration of ozone in the water as temperature increases.

The claimed methods and apparatus achieve the advantages of both high ozone concentration at the workpiece surface, and high temperature, to provide fast reaction times, by using diffusion, rather than dissolution. While only a low amount of ozone can be dissolved within the heated liquid layer on the surface of the workpiece, large amounts of ozone can diffuse through the layer to react at the workpiece surface. Accordingly, the claimed methods and apparatus provide ozone at a rate of at least 90 gph. None of the cited references, alone or in combination, suggest diffusing ozone at 90 gph through a heated liquid layer to react at a workpiece surface, since ozone at such a high concentration would largely be wasted in the prior art apparatuses, due to ozone's inability to effectively dissolve into a heated liquid, or diffuse through a cool liquid.

All of the pending claims describe introducing ozone at a rate of at least 90 grams per hour (gph), or using an ozone supply system having a capacity of at least 90 gph, so that ozone diffuses through a heated liquid layer and reacts at the surface of a workpiece. These claimed features are not taught or suggested by any combination of the cited prior art.

The Office Action, at page 3, states that Applicant's argument regarding ozone reacting at the workpiece surface is unpersuasive because the process as claimed does not include the reaction between the ozone and the workpiece surface. In response, Applicant has amended claim 1 as shown. The remaining independent claims may be similarly amended. Applicant maintains, however, that all of the claims already include the reaction step. For example, claim 26 recites the step of controlling a thickness of the heated aqueous liquid boundary layer to allow for diffusion of the

ozone through the layer and a diffusion controlled reaction at the surface of the workpiece." Independent claims 2, 26, and 27 include similar limitations. Thus, all of the claims do include the limitation that a liquid layer is formed allowing diffusion of ozone through the layer, and a reaction at the workpiece surface.

Li et al., conversely, discloses an adsorbent layer, or "surface diffusion layer" (col. 4, lines 18-60), which is formed by depositing a vapor on the surface of a wafer (col. 4, line 42). The purpose of the adsorbent layer in Li et al. is to inhibit direct reaction of the gas phase with the wafer (col. 4, lines 32-34), in order to eliminate surface roughness (col. 2, lines 38-46). Thus, the intent of Li et al. runs opposite to the pending claims. The intent of Li et al. is to inhibit direct reaction of the gas phase with the wafer surface (col. 4, line 33), or, in other words, to decrease the mean free path through which a cleaning agent must pass, thereby creating a smooth silicon surface, with less pitting and scoring (col. 4, lines 61-64).

Accordingly, Li et al. impliedly encourages using relatively low concentrations of ozone, so that only very low amounts of ozone may directly react with the wafer surface. In contrast, the claimed invention provides an increased amount of ozone to directly react at the workpiece surface, via diffusion of ozone through a heated liquid layer. The heated liquid layer increases the reaction rate, i.e., does not inhibit direct reaction, which is the goal in Li et al. Thus, Li et al. teaches away from using a high concentration of ozone, and clearly does not suggest providing ozone at the claimed rate of at least 90 gph to react at the surface of a workpiece. It is therefore improper to combine Li et al. with any other reference to yield a process or apparatus that uses a boundary layer through which extremely high concentrations of ozone diffuse to react at

a workpiece surface, as claimed (see MPEP § 2145(X)(D)(2), stating that, "it is improper to combine references where the references teach away from their combination").

Matsuoka discloses use of ozone and rotation of the workpieces, as noted in the Office Action. However, Matsuoka teaches away from using a heated liquid. The Office Action, at page 3, states that Applicant's argument that Matsuoka teaches away from using a heated liquid is unpersuasive, because heated liquid is a relative term, and the range of temperature could include the temperature of 25° C, as taught by Matsuoka. Matsuoka, however, clearly teaches away from heating a liquid throughout its specification. For example, Matsuoka states the following:

"A problem with a dry treatment using ozone is that when resists implanted at high doses are treated at relatively high temperatures, pumping, etc., takes place through heat, making some resist residues likely to remain intact." Page 2, lines 56-58.

"Heating the substrates does not permit wet ozone to have well-enough effects, because any thin water film cannot occur even when a wet ozone-containing gas is fed." Page 3, lines 34-35.

Thus, while Matsuoka teaches that liquid may be at a temperature of 25° C, it clearly teaches away from heating the liquid to any significant degree. Indeed, 25° C is virtually room temperature. The present application, conversely, teaches that elevated temperatures are those above 20° C or 25° C, and up to about 200° C (p. 17, lines 17-

18). The application goes on to say that temperatures of 90-100° C, and preferably centering around 95° C, may be used. Thus, the claimed invention is directed to apparatus and methods employing heated liquid, whereas Matsuoka is concerned with keeping temperatures low.

Notwithstanding these facts, even if the Examiner maintains that the 25° C temperature in Matsuoka is "heated" as claimed, then the Examiner should still allow claim 6, which describes "superheated" water, and claims 17, 19, 20, 21, 23, and 27, which describe "a heater", i.e., an element clearly absent in Matsuoka.

Moreover, Matsuoka is directed to various methods of mixing ozone-containing gas with ultra-pure water (p. 3, line 48), not diffusing ozone through a liquid layer to react at a workpiece surface, as claimed. For example, Matsuoka discusses dissolving ozone into a treating solution to mix the ozone with the ultra-pure water (p. 3, lines 56-57). While some amount of ozone in Matsuoka may diffuse through a liquid layer, Matsuoka teaches away from heating the liquid solution to a temperature high enough to facilitate the diffusion of ozone introduced at a rate of at least 90 gph.

Put another way, because Matsuoka teaches away from heating a liquid solution to any significant degree, the rate of reaction in Matsuoka is presumably much lower than with the claimed methods. Thus, if ozone were introduced at the claimed rate of 90 gph in Matsuoka, much of the ozone would not be able to react with the workpiece, due to the low temperatures, and much of the ozone would therefore go to waste. The wasted excess ozone would then have to be destroyed before release (due to the corrosive and toxic characteristics of ozone), which is typically a costly and time-

consuming process. Accordingly, there is no suggestion in Matsuoka to introduce ozone at a high rate, such as the claimed rate of 90 gph.

In fact, Matsuoka suggests, in Example 1, an ozone rate of about 25 gph (based on the 6 lpm and 55,000 ppm parameters). There is no suggestion in Matsuoka to use a higher rate of ozone. The claims, conversely, recite that ozone is provided at a rate of at least 90 gph, i.e., at least a 350% increase over that which is taught in Matsuoka. It would not have been obvious for one skilled in the art to have increased the ozone rate by such a high percentage, since the claimed increase is so large, and Matsuoka discourages heating a liquid layer to a high enough degree to permit such a high concentration of ozone to effectively diffuse through the liquid layer.

In summary, Matsuoka teaches away from heating liquid and from using ozone at 90 gph. As Matsuoka teaches away from heating liquid to a high temperature, it is improper to combine Matsuoka with any reference that teaches the use of a heated liquid to treat a workpiece (see MPEP § 2145(X)(D)(2)).

Bergman teaches uniform etching of a wafer with HF and/or HCl, and makes no mention of using high capacity ozone, or of diffusing large quantities of ozone through a heated liquid layer to react at a workpiece surface. Thus, Bergman does not teach or suggest introducing ozone into a workpiece-containing environment at the claimed rate of at least 90 grams per hour.

Based on the foregoing, the combination of Li et al., Bergman, and Matsuoka does not render the claims obvious, because none of the references, alone or in combination, teach or suggest introducing ozone at the claimed rate of at least 90 gph to diffuse through a heated liquid layer for reacting at a workpiece surface.

In view of the foregoing, it is submitted that the claims are in condition for allowance, and a Notice of Allowance is requested.

Respectfully submitted,

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